

## WIND TURBINE WITH FRICTION DRIVE POWER TAKE OFF ON OUTER RIM

BACKGROUND OF THE INVENTIONFIELD OF INVENTION

This invention relates to a wind turbine and method of operation thereof  
5 for producing energy and, more particularly, to a wind turbine having multi-blades  
(for example eight to twenty), and a ring around the circumference thereof, the  
ring driving energy producing equipment. The blades are shaped with airfoils to  
produce maximum power coefficient.

DESCRIPTION OF THE PRIOR ART

10 Wind turbines, including windmills, are known and are used to power  
energy production equipment including generators, compressors or pumps, as well  
as other devices. It is known to have the wind turbine connected to a shaft and the  
rotational energy in the shaft is then used to drive the energy producing  
equipment. Windmills or wind turbines have gearboxes to transfer the energy  
15 from the blades through the shaft to energy producing equipment. Some wind  
turbine manufactures are using a large diameter direct drive generator connected  
directly to the shaft and running at low rotational speed. Wind turbines with large  
rated electrical output require (<3 MW) large gearboxes and generators. This can  
result in heavy and costly power transmission and energy production equipment. It  
20 is known to use wind turbines to produce electrical energy. Fixed and variable  
speed wind turbines are used to produce electricity with the same frequency as the  
grid. Fixed and variable speed wind turbines have certain advantages and  
disadvantages. Variable speed wind turbines have advantages of reducing the  
dynamic loads on the power transmission systems and have higher power  
25 coefficients than fixed speed wind turbines. Variable speed wind turbine use  
several methods and systems to obtain the same frequency as the grid system of an  
electrical utility. These systems are more costly than those used in fixed speed  
wind turbines. Variable speed operation will allow the wind turbine to start  
producing electricity at lower wind speeds and hence collect more energy. With  
30 variable speed wind turbines, there is a difficulty of producing electricity with the  
same frequency as the grid because the wind velocity constantly changes and  
therefore the speed of rotation of the blades of the wind turbine varies. With

constant speed wind turbines, the frequency of the electricity produced can match the frequency of the grid, but difficulty arises in maintaining a constant speed with variable wind conditions. Further, electrical energy cannot be produced by any wind turbine during periods when the wind is not blowing or is not blowing at a  
5 sufficient velocity to rotate the rotor of the wind turbine.

Wind power is renewable and is a green energy source that is highly desirable as it does not pollute.

### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a wind turbine that can be  
10 controlled to operate energy producing equipment at variable speed rate of speed. It is further object of the present invention to provide a wind turbine without using a step up gearbox.

A wind turbine for producing energy has a rotor on a shaft. The rotor supports a plurality of blades and is rotatably mounted on the shaft. The blades  
15 each have a tip, there being a plurality of tips on the turbine. The tips are connected to support a ring that extends around a circumference formed by the tips. The ring rotates with the blades, the ring having a front and rear surface with rotators mounted to removably contact the ring on the front and rear surfaces. Each of the rotators is connected to energy producing equipment. The rotators  
20 rotate with the ring when the ring rotates, thereby driving the energy producing equipment. The turbine is controlled by a controller.

A wind turbine for producing energy has a rotor on a stationary shaft. The rotor supports a plurality of blades shaped with airfoil sections and is rotatably mounted on the stationary shaft via a hub and a bearing. The blades each have an  
25 outer tip, there being a plurality of outer tips on the wind turbine. The tips are connected to a ring that extends around a circumference formed by the tips. The ring has front and rear surface and rotators are mounted to removably contact the ring on the front and rear surfaces. Each of the rotators is connected to energy producing equipment. When the ring rotates and the rotators are in contact with  
30 the ring, the rotators also rotate, thereby driving the energy producing equipment.

Preferably, the energy producing equipment is selected from the group of a generator, a compressor and a pump.

Still more preferably, the rotators are mounted on a cart with rails having its center of rotation at the center of the tower base circle. The cart being rotatable to move with the wind turbine either toward or away from the wind.

A method of operating a wind turbine for producing energy, said turbine  
5 having a rotor on a shaft, said rotor supporting a plurality of blades and being rotatably mounted on said shaft, said blades each having a tip, there being a plurality of tips on said turbine, said tips being connected to support a ring that extends around said tips, said ring rotating with said blades, said ring having a front and rear surface with rotators mounted to removably contact said ring on  
10 said front and rear surfaces, each of said rotators being connected to energy producing equipment, said rotators rotating with said ring when said ring rotates, said turbine being controlled by a controller, said method comprising operating said turbine by continuously monitoring wind conditions, adjusting yaw, blade orientation and pressure and number of rotators against said ring or removal of  
15 rotators from said ring to produce power output whenever said wind conditions are sufficient.

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial sectional side view of a wind turbine;  
Figure 2 is a front view of a wind turbine;  
20 Figure 3 is an enlarged view of a nacelle and bed plate;  
Figure 4A is a side view of a stationary cone;  
Figure 4B is an enlarged partial perspective view of a spring loaded gate;  
Figure 5A is blade connection to a hub;  
Figure 5B is a partial schematic sectional view of a glade;  
25 Figure 6 is a perspective view of a hub-blade connection;  
Figure 7 is partial perspective view of spokes and said hub-blade connection;  
Figure 8A is a partial perspective view of side view of the hub;  
Figure 8B is a partial perspective view along with lines A-A of Figure 8A;  
30 Figure 8C is a partial perspective view along the lines B-B of Figure 8A;  
Figure 9 is a partial perspective view of a blade-ring connection;  
Figure 10 is a perspective view of a ring section;  
Figure 11 is a top view of the ring section and part of a ring;

Figure 12 is a side view of the ring section;

Figure 13 is a perspective view of a tire connected to a shaft of a generator;

Figure 14 is a perspective view of two opposing tires and generator;

5 Figure 15 is a partial perspective view of a power production equipment cart;

Figure 16 is a side view of a first section of a tower;

Figure 17 is a side view of a second section of the tower;

Figure 18 is a side view of a third section of the tower;

10 Figure 19 is a partial perspective view of the third section of the tower on a foundation;

Figure 20 is a top view of the tower and foundation shown in Figure 19;

Figure 21 is a partial sectional side view of the tower and foundation

Figure 22 is a partial perspective view of a ring section with a brake  
15 system mounted thereon;

Figure 23 is an enlarged partial perspective view a rail cover layout ; and

Figure 24 is a graph of the operation of the yaw system.

### DESCRIPTION OF A PREFERRED EMBODIMENT

In Figures 1 and 2, a turbine 2 has a rotor with a hub 6 and a plurality of  
20 blades 10 extending outward from a root 3 to a tip 12. Preferably, the wind turbine has eight to twenty blades. Connected to and supported by each of the tips 12 is a ring with a front surface 14 and a back surface 62. Rotators 18 are located and mounted to be removably placed into contact with the front surface 14 and back surface 62 as the ring 1 rotates. The rotators each have a shaft 19 which is  
25 connected to energy producing equipment 20. The rotators are preferably tires mounted on a rim 34. The tires are preferably made of rubber. Steel or metal wheels can also be used as rotators. The energy producing equipment includes generators, compressors, pumps and the like. When the energy producing equipment is a generator, the rotation of the wind turbine 2 will cause the front  
30 surface 14 and back surface 62 of the ring to rotate. The tires will also rotate when they are in contact with the ring 1, thereby driving the generators. Preferably, each tire is connected to a separate generator. Also preferably, every rotator, shaft and generator on the front surface 14 of the ring 1 has a corresponding rotator, shaft

and generator on the back surface 62. The corresponding rotator is preferably mounted and controlled to removably contact the back surface simultaneously with the front surface rotator so that when a rotator is in contact with the ring on the back surface, the corresponding rotator on the front surface will also be in  
5 contact with the ring. Similarly, when a rotator on the front surface is moved out of contact with the ring, the corresponding rotator on the back surface will also be moved out of contact with the ring. The corresponding rotator is always located directly behind the rotator on the front surface. In this way, the pressure on the ring from front and back is equalized at all times so that the ring is not unbalanced  
10 by force exerted by the rotators 18. The rotator 18, shaft 19 and energy producing equipment 20 of each mechanism are mounted on a moving base 21. All the mechanisms are mounted on a cart 22 having steel wheels 24 allowing the cart 22 to travel on a rail 26 when required to turn the turbine 2 toward or from a direction of the wind. A hydraulic supply 33 will provide the necessary hydraulic pressure  
15 to move the mechanisms. The electrical current produced by the turbine is transmitted by the generator cables 23 to the transformer 29 via a slip ring 25 and a main electrical cable 28.

In Figures 1 and 2, it can be seen that the blades 10 are connected to the hub 6 and the hub 6 is mounted on a stationary shaft 8 via a bearing 5. A stationary  
20 cone 4 is mounted on a front side of the stationary shaft 8. The stationary cone 4 is fixed to the stationary shaft 8 by spokes 15 and a hollow shaft 16. The cone is equipped with spring loaded gates 31, which start allowing air to pass through the cone 4 at high wind speeds.

The stationary shaft 8 is fixed on a bedplate 13 by a front mounting 9 and a  
25 rear mounting 11. The bedplate 13 is mounted on a tower 17, which is fixed to a foundation 27. The foundation 27 is constructed into the ground 30.

In Figure 3, an electrical motor 35 will be used to power a yaw mechanism. The motor 35 will drive a gear reducer 36 with a shaft 39, two locating bearings 37, 38 and a pinion 40. The pinion 40 will drive a slew bearing 41 mounted to the  
30 bedplate 13 by bolts 42 and to a tower flange 43 by bolts 44. The tower flange 43 is welded to the tower 17.

Figure 4A shows an enlarged side view of the cone 4. A hollow shaft 16 is fixed to the stationary shaft 8 and provides the necessary support for the radial

spokes 15 and outer spokes 45. A spring loaded gate 31 (as shown in detail in Figure 4B) has a spring 46 and a hinge 48 keeping the gate closed at low wind speeds. The gate will start to open under high wind speed allowing air to pass through the cone. The spring 46 is mounted on a base 47 supported by the radial  
5 spokes 15 of the cone.

Figure 5A is a perspective view showing the blade to hub connection 3. The blade 10 has a supporting shaft 49 which extends from the root of the blade to the tip (not shown in Figure 5A). The blade root flange 50 is welded to the support shaft 49 having bolt holes 51. This design is for a stall regulated  
10 operation, which does not require a pitch mechanism. The blades 10 can be mounted on a slew bearing and have an electrical motor and a gear reducer (similar to the mechanism shown in Figure 3 for the yaw drive) to provide a pitching mechanism for the blades 10.

In Figure 5B, there is shown a schematic sectional view of the blade 10. It  
15 can be seen that the blade 10 has an air foil shape with an outer wall 110, ribs 112 and a blade shaft 114. The blade 10 has a D-shaped spar section 116 and a trailing edge section 118.

Figure 6 is a perspective view showing the hub blade connection 54. The blade root flange 50 from Figure 5A (not shown in Figure 6) is mounted on a hub  
20 blade mounting flange 52. The hub blade mounting flange 52 (shown in Figure 5A, but not shown in Figure 6) has bolt holes 53 facing the blade root flange bolt holes 51.

Figures 7, 8A, 8B and 8C show the hub blade connection 54 connected to hub rings 56 via mounting bolts 55. The hub rings 56 are connected to a center of  
25 the hub 6 by spokes 57.

Figures 8B and 8C show a partial perspective view of a side wall 120 of the hub 6 and a cross member 122.

Figure 9 shows a blade to ring connection 12. The blade 10 has a supporting shaft 49 which extends from the root of the blade to the tip (not shown in Figure 9). The blade tip flange 58 is welded to the blade support shaft 49  
30 having bolt holes 59. Figure 9 shows an opposite end of the blade 10 from the end shown in Figure 5A.

Figures 10, 11 and 12 show the front face of the ring section 14 and back face of the ring section 62, the ring section has a blade mounting flange 60 with bolt holes 59 facing the bolt holes of the blade tip flange 59. Each ring section is connected to the adjacent ring section by a mounting 32. Ring sections have holes 5 61 to reduce the weight. Each ring section 14 has a curvature (Figure 12) so that the ring sections can form a circle (see Figure 2). The portions of the ring sections that the tires contact are flat.

Figure 13 shows a perspective view of a front tire-generator mechanism 79 consisting of a rotator 18 (preferably a tire) mounted on a rim 34 which is 10 connected to a shaft 19 that drives the power generation equipment 20, which in this Figure is an electrical generator. A brake disc 67 is mounted on the shaft 19 by a flange 66. Brake calipers 68 are located around the brake disc 67 (first brake option). A power generating equipment mounting 73 is fitted with rolling elements 75, which are fixed to a mounting base 21. A spring 69 is mounted 15 around a hydraulic cylinder 70, which is connected to the shaft 19 and mounted on support structure 64. Another spring 71 is mounted around a hydraulic cylinder 72, which is connected to the power generation equipment mount 73 and mounted on the support structure 64. The springs 69, 71 will provide the required pressure to connect the rotator 18 to the front face ring 14 to transmit the required power. 20 The hydraulic cylinders 70, 72 provide the required force to disconnect the rotator 18 from the front face ring 14. A lock 74 locks the power generating equipment mounting 73 into place when the rotator 18 is fully disconnected from the front face ring 14, relieving the two hydraulic cylinders 70, 72. A small hydraulic cylinder 76 actuates the lock 74. The hydraulic cylinder 76 is mounted on a 25 support structure 77. The two hydraulic cylinders 70, 72 are supplied by hydraulic pressure by hydraulic lines 78 connected to the hydraulic supply 33. The hydraulic cylinders 70, 72 are mounted on a support structure 64, which is supported by an angled structural member 65, to provide the required stiffness. An electrical cable 23 is used to connect the power generation equipment 20 (generator in this case) 30 to the slip ring 25. The whole mechanism is mounted on the cart 22.

Figures 14 and 15 show the front tire-generator mechanism 79 and a back tire-generator mechanism 80, which are mounted on the cart 22. The mechanisms 79, 80 are identical to one another and are mirror images of one another. An

electrical cable 23 connects the power generation equipment 20 (generator in this case) to the slip ring 25, which is connected to the transformer 29 by an electrical cable 28. The cart 22 has a cover 82 protecting the equipment from the environment and a brush 81 scraping the front face ring 14 (not shown in Figures 14 and 15) and the back face ring 62. The cart 22 is mounted on a steel wheels 24, the wheels being connected to a shaft 84 having a bearing 83. Inner steel retention wheels 85 are used to prevent the cart 22 from tipping to the sides. The steel wheels 24 are rotate on the rail 26.

Figure 16 shows a first tower section 86 having a top first section tower flange 43 that is fitted with bolts holes 44. Several service station supports 87 are located on the inside of the first tower section 86. The first tower section 87 is constructed from hollow steel and is fitted at the bottom with a flange 89 having bolt holes 88 to connect it to the next tower section.

Figure 17 shows a second tower section 90. A top flange 89 is fitted with bolts holes 88 to connect the section to the first tower section 86 (not shown in Figure 17). Several service station supports 87 are located on the inside of the second tower section 90. The second tower section is constructed from hollow steel and is fitted at the bottom with a flange 92 having bolts holes 91 to connect it to the next tower section.

Figure 18 shows the third tower section 93. A top flange 92 is fitted with bolts holes 91. Several service station supports 87 are located on the inside of the third tower section 93. The third tower section 93 is constructed of hollow steel and is fitted with a flange 95 having bolts holes 94 to connect it to the foundation flange 98 (see Figure 19).

Figures 19, 20, and 21 show the third tower section 93 connected to the foundation flange 98 having steel support triangles 96 to prevent bending of the third tower section 93. The foundation steel flange 98 is connected to a steel shaft 100 and steel rings 99 embedded into the reinforced concrete foundation 27.

Figure 22 is shows the second option for the brake system by fitting calipers 104 actuated by a hydraulic cylinder 101 having a hinged mechanism 102 at the front ring side 14 and the back ring side 62 (not shown) to provide the required braking power to stop the wind turbine 2 from rotating. Hydraulic cylinders 101



are supplied with hydraulic fluid through hydraulic supply lines 103, which are connected to the hydraulic supply 33.

Figure 23 shows a rail cover 106 mounted on small wheels 107. The small wheels 107 move on the rail 26 with the cart 22 to keep the rail 26 protected from the outside environment. A steel wheel cover 105 protects the steel cart wheels 24 from the outside environment. The steel wheel cover 105 can move up and down to allow access to service the cart steel wheels 24. The same reference numerals are used in Figure 23 as those used in Figure 15 to refer to those components that are identical.

## OPERATION AND CONTROLS

The wind turbine of the present invention has the capacity to collect and transmit power in the range of 50 kilowatts to 7.5 megawatts and has a low capital cost when compared to conventional power wind turbines rated in the same range. The wind turbine will rotate with relatively low rpm when compared to conventional wind turbines (rpm will depend on the number of blades, when using 20 blades the rotational speed is between 1 and 5 rpm). This low rotational speed will provide long service time for the rotating parts requiring less maintenance, produce less noise than conventional wind turbines, and the turbine has better control characteristics than conventional designs. The wind turbine of the present invention can be designed to compress air and to store that compressed air for use during peak hours for the electrical system. The number of compressors used depends on the power delivered by the wind turbine and the capacity of each compressor. Compressed air can be stored in underground storage pipes, tanks, caverns or in the body of the wind turbine tower. Heat exchangers can be used to extract the heat from the compressed air storage and re-provide the same heat for the compressed air later for the regeneration process.

The wind turbine of the present invention can be used to drive an air-water engine consisting of several cylinders. Air-water systems have been previously described. A Pelton wheel is preferably used with the air-water system to produce electricity as described in US Patent No's. 6,672,054 and 6,718,761.

A single rotator can be designed to drive different types of energy production equipment. For example, a rotator could be alternatively connected to a pump, compressor and generator with a controller to control which type of energy

producing equipment is being driven at any particular time. The wind turbine can be constructed to be strong enough to have the rotators contact one surface of the ring only. Also, the ring can be designed with projection and indentations thereon corresponding to projections and indentations on the rotators. The ring could also  
5 be designed in separate parts with the front surface located on a separate component from the back surface.

A control system for the wind turbine is as follows:

- Operational sequence system.  
10 The system will receive external signals according to the operating conditions, above all the wind conditions and operator's intentions, which will determine the set values for the control system.  
Objectives of the operational sequence system are as follows:  
1- Ensure fully automatic operation.  
15 2- Recognize hazards and activate the corresponding safety systems.  
3- Meet special requirements of the operator.

- Supervisory systems controls.  
The system will take into consideration the following:  
20 1- Yaw motion.  
2- Speed and power output.  
3- Mode of operation.

The control system will take into consideration the following:

25 1- Wind Measurement System:

Operational sequence and yawing requires measuring the wind speed and direction.

Electrical motor-driven yawing system is proposed for the multi blade wind turbine, which requires information about wind direction.

30 Operational sequence requires the wind speed information in order to switch between different modes of operation.

Measuring of the wind speed could be preformed indirectly by means of the electrical output. The rotor itself is the only representative wind measuring instrument of a turbine.

5      2- Yaw Control:

The wind measuring system provides a mean value of the wind direction over a period of ten seconds. This value is compared with the instantaneous azimuth position of the nacelle every two seconds. If the deviation remains below 3 degrees, the yaw system will not be activated. If the determined yaw  
10      angle is above this value, the time for correction is determined by a pre-programmed function. An operating diagram for the yaw is shown in Figure 24.

If the yaw angle is small (0 to 20 degrees), yawing is carried out within 60 seconds.

15      If the yaw angle is 20 to 50 degrees, yawing is carried out within 20 seconds. If the yaw angle is large (exceeds 50 degrees), yawing is carried out immediately.

The rotor yaw speed is low and to be determined after taking into consideration the gyroscopic moments. Since the yaw speed is the same for  
20      small and large yaw movements of the turbine, large movements will take much longer to complete than small movements. For small movements, the commencement of yawing is delayed as the wind may change direction within the delay period. For large movements (exceeding 50 degrees), the yaw movement commences immediately.

25

3- Power and Speed Control by Rotor Blade Pitching when using a Blade Pitching Mechanism:

The objective is to obtain a stable operating point by the following means:

- 30      a- Controlling the blade pitch, which will control the rotor's primary energy.
- b- Control of the generator voltage and reactive power.
- c- Loading and unloading of the generators.

Extremely brief fluctuations of less than few seconds are reduced by the rotor blades, friction ring, and actuating elements mass inertia. Combined speed and power control system is proposed for the control of the Multi Blade wind turbine.

5

#### 4- Mechanical Drive Train:

The inertia of the rotating masses including:

- a- The Rotor.
- b- The Friction ring.
- 10 c- The Rotator and shaft
- d- The Generator Rotor.

The stiffnesses, the damping behavior, and vibration behavior are different than those of a conventional wind turbine as the power transmission  
15 system is unconventional using a friction drive and multi-generator system.

#### 5- Full and Partial Load Operation:

In full load operation the pitch control is active (when using a pitch mechanism), so that rotational speed and power can be adjusted to the nominal  
20 values. The speed controller can be provided with a degree of insensitivity to reduce the number of pitching processes.

When not using a pitch mechanism, the blades will be stall regulated. Hence, the angle of the blades will be high enough at high wind speeds to ensure stall to reduce the loads on the blades.

25 At partial load, control of the power output and rotor speed is carried out by variation of the generator torque and loading and unloading of the Tire-Generator mechanisms (if the mechanisms is not in contact with the friction ring all the time).

30 Using the MPPT (Maximum Point Power Tracking) process approach to control the rotor speed achieving the optimal rotor power coefficient. This is achieved by determining the set point for the power maximum by incremental speed variation, in the form of a scanning process.

Control System Actions:

- 1- Acquisition of the input data necessary for operational sequence as wind speed and wind direction.
- 2- Automatic operational sequence, with manual operation for special cases.
- 3- Activation of the safety and emergency systems taking into consideration shutdown of the rotor even with out electric control system.
- 4- Adaptation to operation on the grid.

Operational Cycle:

Operational cycle includes the following:

- System check at stand still: checking of the operational status of the most important systems. The rotor is arrested by the parking brake and pitch angle (when pitch mechanism is used). If no faults are indicated in the system check, the turbine is ready for further progress in the operational cycle.
- Yawing: if the system check is positive, the yaw system is activated, the rotor still being parked. The turbine is yawed to the wind direction (turbine yawing includes moving the Rotor head and the Tire-Generator Mechanism Cart at the same time) and it is checked whether the wind speed is within the operating range of 4 to 25 m/sec.
- Start up: pitching of the rotor blades into the starting position (when using a pitching mechanism), subsequently the mechanical rotor brake is released. The rotor starts to turn and accelerates up to the synchronization speed of the generator, corresponding to 90% of the nominal speed. Start loading of the Tire-Generator Mechanism (Tire-Generator mechanisms may be in contact with the friction ring all the time or may be loaded as the wind speed increase). The blade pitch angle is controlled according to a preset speed increase (when using a pitch mechanism).
- Normal operation: if the generator's connection to the grid has been established the power output into the grid begins (cut-in wind speed). The

turbine operates at partial load if the wind is below rated value. Under these conditions the pitch angle is set to a predetermined value (when using a pitch mechanism), which is the angle of the best compromise close to the optimum in the rotor power characteristics (variable blade pitch operation under partial load may be required). When operating at full load, the blade pitch is then controlled such that the rated power is not exceeded. When using a stall regulation as the state of pitch mechanism, the blades will stall to avoid overrating the wind turbine and this will ensure that the rated power is not exceeded.

- Shut-down: if the wind speed drops below the cut-out wind speed or if loaded operation is to be interrupted, the rotor will be brought to the standstill. During the shutdown process the rotor blades are pitched in order to achieve a defined speed decrease (when using a pitch mechanism). The generators are taken off the grid, within the range of 92% to 90% of the rated speed. Rotor standstill is achieved by setting the speed set-point value to zero. The rotor blades pitch to an angle of approximately 80 degrees (when using a pitch mechanism). This brakes the rotor aerodynamically to a low idling speed. Complete standstill is achieved by applying the mechanical brake. When using stall to regulate the blades, the turbine is yawed out of the wind direction. This will reduce the rotor speed to idling speed. Complete standstill is achieved by applying the mechanical brake.

The method of operating the wind turbine to produce energy can vary. The turbine is preferably operated as a variable speed turbine and the controller is used to control the operation of the turbine in light of the wind conditions. The controller preferably continually monitors the wind conditions and when the conditions are sufficient to generate energy from the wind turbine, the controller automatically adjusts the yaw, orients the blades and when the blades are rotating at sufficient rpm, places the appropriate number of rotators with the appropriate pressure against the ring. In stronger wind conditions, the controller will place more rotators against the ring and in weaker wind conditions, the controller will remove some or all of the rotators from the ring. When wind conditions are not

sufficient to generate energy, the controller will shut the turbine down by applying a mechanical brake to the turbine to stop the blades from rotating and also orienting the blades and adjusting the yaw of the turbine to reduce the effect of the wind. As the wind conditions improve, the controller will again release the brake, adjust the yaw and orient the blades to cause the blades to rotate at sufficient speed to generate energy. The controller will then place the rotators in varying numbers against the ring and remove rotators as required as the wind conditions continue to vary. The process will be repeated as the turbine continues to operate.

Numerous variations can be made to the invention within the scope of the attached claims. For example, the front and rear surfaces of the ring can have a plurality of alternating ridges and indentations thereon corresponding to alternating indentations and ridges on said rotators. The wind turbine has a controller that automatically controls the operation of the turbine.